coatings

Editorial

Synthetic and Biological-Derived Hydroxyapatite Implant Coatings

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Bone and joint defects or diseases, coupled with edentation, pose challenging and commonly encountered clinical issues with a significant incidence in the medical domain. These conditions are primarily attributed to factors such as aging, trauma, infections, tumor resection, or congenital/hereditary disorders. It is important to acknowledge that the prevalence of these medical issues is anticipated to rise further due to the global increase in life expectancy [1]. Currently, orthopedic and dental implants predominantly utilize materials crafted from titanium (Ti) and its medical-grade alloys, owing to their exceptional performance attributes [2]. In recent years, there has been a growing interest among researchers in biodegradable materials, specifically magnesium and its alloys [3]. The need for a secondary surgical intervention to remove the implant, once the tissue has adequately healed, is eliminated when employing biodegradable implants. This stands as one of the most notable advantages associated with this type of devices.

A significant challenge in the biomedical field is the development of implants that can seamlessly integrate into the living body [4]. Despite ongoing efforts to enhance the corrosion resistance (an electrochemical process involving both reduction and oxidation reactions) of metallic materials, the underlying issue continues to be persistent. A viable approach to regulating the corrosion process and inhibiting direct interaction between body fluids and implants involves the use of coatings, which function as protective layers at the human body ("host")–implant interface [5]. To optimize this interface, the surface of the metallic substrate is typically coated with a bioceramic material. The objective of these coatings is to enhance fixation and expedite the osseointegration rate at the living tissue–implant interface, thereby improving its long-term functionality. Currently, the "gold" standard material utilized for coating implants is hydroxyapatite (HA). HA stands as one of the most extensively researched calcium phosphates (CaPs) for osseointegrative applications, owing to its exceptional biocompatibility [6], high biomineralization capacity, thermodynamic stability in body fluid environments [7], good osteoconductivity [8], and chemical–structural similarity to the inorganic component of human bone tissues [9]. HA can be either synthetically produced or derived from natural resources. It is important to highlight that synthetic HA is typically produced using intricate and chemically demanding protocols [1]. Therefore, an alternative and sustainable approach for HA production involves extracting it from abundant biological resources, such as animal bones resulting from the food-processing industry, fish discards, eggshells, sea shells, corals, and so on) [10,11]. Studies have reported that biological-derived HA (BHA), when compared to synthetic HA, comprises a variety of trace elements (e.g., Na, Mg, Sr, and K) that play specific bio-functional roles [12]. Additionally, BHA exhibits enhanced mechanical performance [13], a more dynamic response to the environment, tends to elicit less intense inflammatory reactions, and has demonstrated excellent biocompatibility, bioactivity, and osseoconduction characteristics [14].

It is worth noting that HA constitutes the primary inorganic component of bone tissue, featuring a structure with a unique affinity that permits a broad range of substitutions and ion doping. This resemblance to the composition found in natural, healthy bones includes elements such as Mg, Si, Zn, Sr, Li, and CO_3^{2-}. The objective is to foster bone remodeling, exhibit antibacterial activity, and promote enhanced bio-integration.

Among the various surface modification methods, the plasma spray technique is commonly employed in commercial applications to coat implants with bioactive ceramics, particularly HA coatings. Nevertheless, issues have arisen concerning the poor clinical performance of traditional plasma-sprayed coatings. Hence, within this Special Issue, various techniques have been introduced as alternative methods to plasma spray for coating metallic implants across diverse medical applications. These methods encompass, but are not limited to, pulsed laser deposition (PLD), magnetron sputtering (MS), electrophoretic deposition, dip-coating, hydrothermal treatment, and biomimetic coating [1,2,13,15–24].

The topic of interest for this Special Issue is, therefore, dedicated to the synthesis and characterization techniques of HA-based coatings. Both synthetic and naturally derived HA materials were considered. One should emphasize that a special focus was dedicated to the preparation of bioactive and biodegradable HA-based biomaterials with tunable properties. These biomaterials are intended for applications in bone repair and regeneration, tissue engineering, orthopedics and biosensing, dental implants, and in vivo applications.

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